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REMARKS

Status of the claims:

Claims 1-13 are pending with claims 6-9 having been withdrawn from a prior restriction requirement. Thus, claims 1-5 and 10-13 are pending and ready for further action on the merits. Reconsideration is respectfully requested in light of the following remarks.

Rejections under 35 USC §§103

Claims 1 and 3 are rejected under 35 USC §102(b) as being anticipated by Ota '008 (JP 06-57008).

Claims 2 and 10-12 are rejected under 35 USC §102(b) as being anticipated by or alternatively under 35 USC §103(a) as being unpatentable over Ota '008.

Applicants traverse.

Applicants, herein, further support the arguments made in the response filed December 23, 2003. In particular, Applicants submit that the melt-kneading in Ota '008 does not happen in the side feeder but rather in the extruder. Applicants herein, attach a selection from the "Handbook of Plastic Materials and Technology" ("Handbook of Plastic Materials and Technology", Ed. Rubin, Irvin, I., New York, 1990, pp. 1179-1180), which describes the major functions of extruders as well as the nomenclature of specific types of extruders and further supports

the arguments presented in the response submitted December 23, 2003. Applicants respectfully point out that on page 1180 of the "Handbook of Plastic Materials and Technology" it says:

*Some extruders, called melt-fed extruders, are charged with molten polymer; their only function is to mix, pump, and force the material through die. In most extruders, called plasticating extruders, the machine is fed with solid material and, therefore, solids conveying and melting are important functions to be performed.*

From this passage, it should be apparent that the majority of extruders are extruders in which a solid material is fed into the extruder. Other types of extruders, which accept molten polymers are non-conventional extruders.

Ota '008 fails to use any term that indicates that the extruder used in Ota '008 is a melt-fed extruder. As was pointed out in the response of December 23, 2003, one of ordinary skill in reading Ota '008 would understand that "feeder" as recited in Ota '008 refers to equipment for conveying a polymer powder or pellets and does not refer to melt kneading. Feeding a solid material into the extruder is consistent with the above passage cited from the "Handbook of Plastic Materials and Technology" as most extruders are fed with solid materials. Thus, Applicants assert that one of ordinary skill in the art would assume that a solid material is fed into the extruder absent any teaching otherwise.

Applicants submit that there is nothing to support the Examiner's assertion that component "C" has been melted in the side feeder. At page 14, lines 6-9 of Ota '008, it is described that component "C" is supplied to the side feeder from the capacity feeder or weight feeder and supplied to the main body of the extruder from the side feeder. This passage says nothing of melting component "C". Moreover, as was pointed out in the response of December 23, 2003, Applicants assert that the sentence that bridges pages 13 and 14 of the translation of Ota '008 leads further credence to the interpretation that component "C" is fed into the extruder as a solid material. The sentence recites:

*The method for manufacturing the resin composition of the present invention is a method that feeds the above-mentioned components (A) and (B) to the above mentioned extruder by the main feeder, melt-kneads them, and melt-kneads the component (C) by the side feeder, so that a resin composition is manufactured by only one cycle of melt-kneading.*

Applicants assert the phrase "and melt-kneads the component (C) by the side feeder" really means "and melt-kneads the component (C) in the above-mentioned extruder, which is fed by the side feeder". Applicants assert that this is the only way that this sentence can be interpreted because the next part of the above cited passage (from the sentence that bridges pages 13 and 14) says, "so that a resin composition is manufactured by only one cycle of melt-kneading".

Applicants respectfully point out that the Examiner's interpretation is not logical for the following reasons. The Examiner in the Office Action states:

*However there is nothing contradictory to the disclosure that the resin composition is manufactured by only one cycle of melt kneading despite the fact that the side feeder kneads prior to feeding to the extruder. It does not appear to the Examiner that melt kneading in a side feeder and an extruder would amount to two cycles of melt kneading in that a material which is already melted (such by a side feeder) could not be said to be also melted in the extruder given that already melted material cannot be melted. . . . There is no reason that melt kneading cannot take place in the side feeder as well as in the extruder. (emphasis added)*

Applicants respectfully point out that there are two processes that happen in melt-kneading, 1) melting and 2) kneading. The Examiner asserts that melting may happen in the side feeder and also notes that kneading happens in the side feeder. This would be one cycle of melt kneading. If component "C" is fed to the extruder in a melted state (as asserted by the Examiner) and kneaded with components "A" and "B", which in turn must be melted and kneaded, this would be the second cycle of melt kneading. In other words, if a melted component "C" were added to the extruder, two cycles of melting and kneading would still be required. However, Ota '008 says: "a resin composition is manufactured by only one cycle of melt-kneading". One should note that Ota '008 does not say "component C is only manufactured by one cycle of melt kneading", which one might

tenuously argue would be consistent with the Examiner's interpretation. The only interpretation that is consistent with one cycle of melt kneading as disclosed by Ota '008 is Applicants' interpretation (i.e., component C is fed into the extruder as a solid material and one cycle of melt-kneading takes place in the extruder). Any other interpretation of what occurs would mean that at least two cycles of melt kneading take place, which would directly contradict the teaching of one cycle of melt-kneading as disclosed Ota '008. Finally, the Examiner's statement:

*There is no reason that melt kneading cannot take place in the side feeder as well as in the extruder*

suggests a two-cycle process - one cycle of melt kneading that occurs in the side feeder and one cycle of melt kneading that occurs in the extruder. This is inconsistent with the teaching in Ota '008. In other words, Ota '008 simply fails to disclose or suggest feeding molten rubber into the extruder. For the above reasons, withdrawal of the rejections is warranted and respectfully requested.

With the above remarks, Applicants believe that the claims, as they now stand, define patentable subject matter such that passage of the instant invention to allowance is warranted. A Notice to that effect is earnestly solicited.


If any questions remain regarding the above matters, please contact Applicant's representative, T. Benjamin Schroeder (Reg. No. 50,990), in the Washington metropolitan area at the phone number listed below.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

Respectfully submitted,

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Attachment: *Handbook of Plastic Materials and Technology*,  
Ed. Rubin, Irvin, I., New York, 1990, pp. 1179-  
1180

# HANDBOOK OF PLASTIC MATERIALS AND TECHNOLOGY

*Edited by*

Irvin I. Rubin

Robinson Plastics Corporation



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# 87

## EXTRUSION

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### 87.1 DESCRIPTION AND HISTORY OF PROCESS

Extrusion is the process of forcing material through an opening. Many different materials are processed by extrusion: metals, foodstuffs, ceramics, and plastics. The machine on which the process is performed is an extruder. The extruder is indisputably the most important piece of machinery in the polymer processing industry. Many different types of extruders are used to extrude plastics, the main ones being screw extruders, disk extruders, and reciprocating extruders. Screw extruders consist of at least one Archimedean screw that rotates in a stationary extruder barrel. Single-screw extruders have only one screw; multiscrew extruders have two or more screws. Single-screw extruders are the most common type of extruder used in the plastics industry, and, accordingly, are the focus of this section.

In standard single-screw extruders, the screw rotates but does not move axially. However, there are screw extruders designed to allow axial movement of the extruder screw in addition to rotational movement. These machines are called reciprocating screw extruders and are widely used in injection-molding machines. The ability to move the screw axially allows the reciprocating screw extruder to operate in a cyclic fashion, which is necessary in the injection molding process. The standard single-screw extruder operates in a continuous fashion, which is beneficial in the production of long lengths of product with constant cross sectional shape, such as tubing, film, and profiles.

The first machines for extrusion of plastic were built around 1935. They were primarily used to extrude rubber. Shortly after the introduction of the single-screw extruder, the twin-screw extruder was developed in Italy in the late 1930s. The early screw extruders were quite short with a length to diameter (L/D) ratio of about 5. They were generally heated with steam. Later, the machines became longer and electric heating began to displace steam heating. Modern single-screw extruders range in length from 20 L/D to about 30 L/D, with some specialty machines being considerably longer than 30 L/D. Most modern extruders now use electric heating.

#### 87.1.1 Functional Process Description

There are six major functions performed in screw extruders: solids conveying, melting or plasticating, melt conveying or pumping, mixing, devolatilization, and forming. Devolatilization is not performed on all extruders, only on those specially designed to extract volatiles from the polymer. These devolatilization extruders are usually referred to as vented extruders. Two other functions that are not performed on all extruders are solids conveying and

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melting. Some extruders, called melt-fed extruders, are charged with molten polymer; their only function is to mix, pump, and force the material through die. In most extruders, called plasticating extruders, the machine is fed with solid material and, therefore, solids conveying and melting are important functions to be performed.

**Solids Conveying.** Solids are conveyed in two regions: the feed hopper and the screw extruder. The solids conveying in the feed hopper is generally a gravity flow of particulate polymer; the material moves down the feed hopper by its own weight. Unfortunately, this does not always work without problems. Some materials have poor bulk flow characteristics and may get stuck in the feed hopper. This problem is called arching or bridging. It is likely to occur when the particle shape is irregular, when the particle size is small, and when the internal friction of the bulk material is high. Highly compressible bulk materials are also quite susceptible to solids conveying instabilities. Feed hopper can be designed to avoid bridging if the appropriate bulk flow properties are known. The most important property is the internal shear strength of the bulk material as a function of normal stress: this functional relationship is referred to as yield locus (YL). For noncohesive or free-flowing materials the shear strength is a unique function of normal stress and also of consolidation time. These concepts and their application to feed hopper design have been described in detail by Jenike.<sup>1,2</sup> Theoretical and experimental work on gravity solids conveying in feed hoppers and the design criteria for feed hoppers are reviewed in a recent book on polymer extrusion.<sup>3</sup>

If a solid conveying problem does occur in the feed hopper there are several measures that can be taken to eliminate the problem. In many cases, a vibrating pad will be attached to the hopper to dislodge any bridges that may form. In some cases, stirrers are incorporated into the hopper to prevent the material from settling and consolidating. In other cases, a crammer feed is employed to force to bulk material from the feed hopper into the extruder. Figure 87.1 illustrates these devices.

**Drag Induced Solids Conveying.** Once the bulk polymer falls down into the screw channel the transport mechanism changes from gravity induced solids conveying to drag induced solids conveying. The polymer moves forward as a result of the rotation of screw in the stationary barrel. The frictional forces acting on the polymer particles are responsible for the motion of the polymer. The loose particles are compacted rather quickly into a solid bed. The compacting occurs because the polymeric particles are conveyed against a certain pressure. The pressure increase along the solids conveying zone causes the compaction of the solid bed. Once the solid bed is sufficiently compacted, it moves in plug flow. Thus, all elements of the solids bed at any cross section move at the same velocity; there is no internal deformation in the solid bed.

There are two main frictional forces acting on the solid bed; one at the barrel surface and one at the screw surface. It is important to realize that the frictional force at the barrel surface is the driving force for the solid bed and the frictional force at the screw surface is the retarding force on the solid bed. The magnitude of the frictional force is determined by the local coefficient of friction and normal stress between the two surfaces in sliding contact. The frictional stress  $\tau$  can be expressed as:

$$\tau_f = f \cdot \sigma_n \quad (87.1)$$

where  $f$  is the coefficient of friction and  $\sigma_n$  the normal stress. Equation 87.1 is generally known as Coulomb's law. Thus, the frictional force is large when the coefficient of friction and the normal stress are large. The fact that the frictional force at the barrel constitutes the driving force can be appreciated if an extreme situation is considered. If the frictional force on the barrel were zero, the solid bed would just rotate with the screw and never move forward. This situation is similar to a nut rotating on a bolt when it is free to rotate. However, when the nut is kept from rotating it will start moving forward along the bolt. In